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01 Organisms and Populations

1. Introduction :

The term ecology was coined and described by	–	**E. Haeckel**
Father of ecology	–	**Reiter**
Father of Indian Ecology	–	**Prof. Ramdeo Misra**
First of all term ecology was employed for study of plant by	–	**Warming**

Definition:

The study of interaction or inter-relationship of organisms with their environment is called ecology. **Organism $\rightleftharpoons$ Environment**

Organism and environment are interdependent, inter-related or mutually reactive.

Ecology is a subject which studies the interactions among organisms and between the organism and its physical (abiotic) environment.

Branches of Ecology – It is based on organisation level.

(a) Autecology – Study of the relation of a single species with its environment is known as autecology (Here unit of study is a single species). It is also called species ecology.

(b) Synecology – Study of the relation of the group of different species with their environment is known as synecology. (Here unit of study is community.)

2. Ecological Hierarchy :

Organism → Population → Community → Ecosystem → Biome → Biosphere

$\longrightarrow$

Size → Increase

Complexity → Increase

Note :

- **Landscape : -** It is a unit of land with a natural boundary having a mosaic of patches. These patches generally represent different ecosystem.
  In ecological hierarchy landscape can be present between Ecosystem and Biomes.
- **Habitat : -**Physical area where an organism lives. The physico-chemical (abiotic) components (mainly temperature, water, light and soil) alone do not characterise the habitat of an organism completely; the habitat includes biotic components also – pathogens, parasites, predators and competitors – of the organism with which they interact constantly.
- **Micro climate and Micro habitat :-** Subdivision of habitat is called microhabitat it is an immediate climate (real climate) of an organism which is different from the average climate of region.
  e.g. Forest floor, Burrow and surface of desert.

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Ecosystem

(1) Organism : An organism is the smallest unit of ecological hierarchy and basic unit of ecological study.

- It may be small/large, unicellular/multicellular.
- Fixed life span (birth to natural death) and organized life cycle.
- Ecology at the organismic level is essentially **physiological ecology**. An organism adapts its physiology to its surrounding environment.

ORGANISMS

ANIMALS | **MICROBES** | **PLANTS**

(2) Population : A group of Individuals (members) of same species living at one place (specific geographical area) constitute a population.

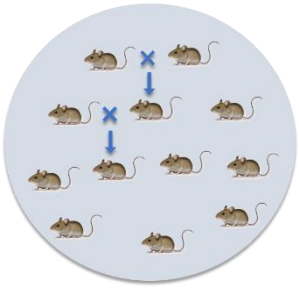
(A) Local Population or demes (Sub groups of population) :- Population of organism inhabiting a particular area. ***e.g.*** ***Homo sapiens*** **inhabiting hills and plains**

(B) Sister population :- Different population of same species of organisms which are found in different places are known as sister population.

(C) Metapopulation :- A set of local population which are interconnected by dispersing individuals.

(D) Species :

Definition - Species is a basic unit of classification, defined as the group of living organisms similar in structure, function and behaviour and produced by similar parents, have common gene pool, can inter breed under natural conditions and reproductively isolated from other group of organism.



Some terms related to species :

- **Endemic Species or Endemism :** A species which is found only in a particular area is known as endemic species. ***e.g.*** *Metasequoia* is found only in valley of China, Kangaroo in Australia.

Kangaroo (Mammalia)

Metasequoia **(Gymnosperm)**

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- **Key-stone Species :** The species which have great influence on the community's characteristics relative to their low abundance or biomass are called key-stone species. The activities of key-stone species determine the structure of the community.
  e.g. Lion in forest, Kangaroo rat in desert, Fig tree in tropical forest, *Pisaster*.

Lion in forest

Kangaroo rat in desert

Fig tree in tropical forest

- **Critical Link Species :** The species which establishes an essential link with other species to help the latter in some vital activity is called link species.
  e.g. Mycorrhizal fungi, many insect species which works as pollinators of flowers.

Mycorrhizal fungi and plants

Bees and plants

(3) Community :

Groups of organisms of different species that live in common area, which are interrelated and interdependent. It is a natural aggregation of plants, animals and microbes (biotic community) interacting in the same environment/area.

Biotic Community = Animal community + Plant community + Microbial community

(A) Characteristics of a community :

(i) Species Diversity :- There are different types of population (species) found in community, this is called species diversity. It depends on size of the area, type of area, type of soil, altitude, climate.

(ii) Dominance :- The highest number of organisms of a species present in community, is called as the dominant species. Whole community is known by the name of that particular dominant species.
e.g. *Prosopis* in Aravalli hills, *Pinus* in Himalaya and mangrove forest.

Pinus in Himalaya

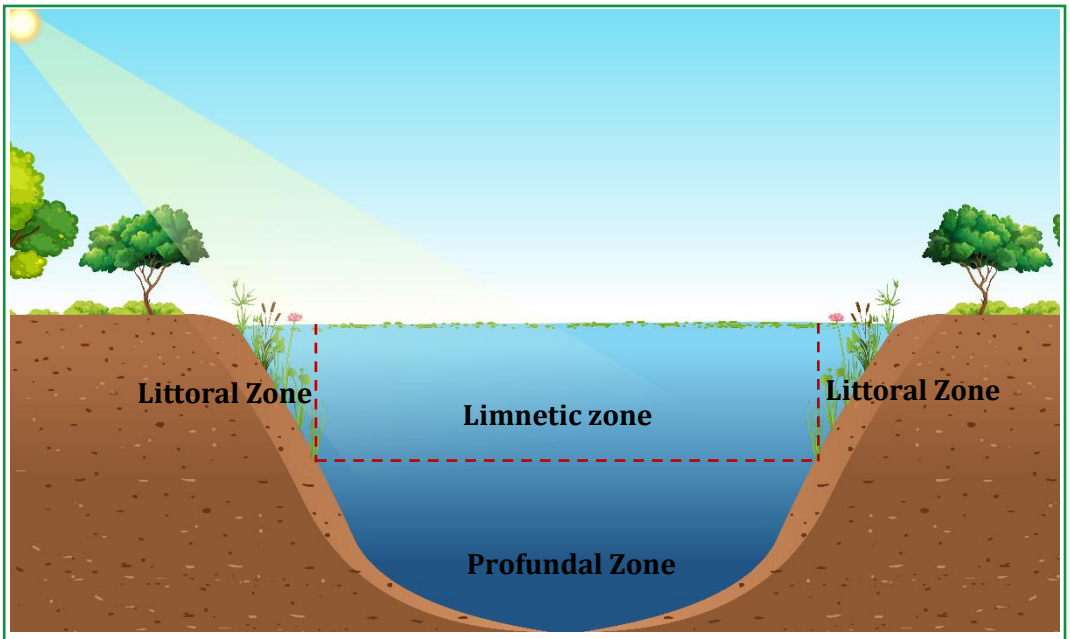
Mangrove forest

(iii) **Stratification :–** The different growth form (trees, shrubs, under shrubs, herbs) determines the structure of a plant community.

Stratification is based on mode of arrangement of various growth forms.

(a) **Stratification in lake :-** In deep lake, zonation or stratification may be according to the need of light. There are three types of zones differentiated in a deep lake.

- **Littoral Zone –** This zone is found at bank of lake where very shallow water or marshy land is present. Rooted vegetation is found in this zone.
- **Limnetic Zone –** This is the zone of lake water, where light reaches in sufficient amount to entire surface area. It means this is not too deep. In this region different types of floating plants (phytoplankton), suspended and submerged plants are present.
- **Profundal Zone –** It is very deep area of the lake where light does not reach up to the bottom. Only heterotrophs are present in this zone.



Stratification in lake community

Note :

Ecotone – The transition zone in between two communities is called ecotone or tension zone. It has greater number of species & density or it is a transition zone between two communities where one type of community is modifying into another type of community is known as ecotone.

Edge effect – Species which occur most abundantly and spend their time in ecotone are called edge species. The tendency to increase variety and density of some organism at the community border is known as edge effect.

(b) **Stratification in forest :–**The clear stratification (vertical arrangement) in various growth forms of plants according to the need of light in any dense forest.

Surface dwellers → Herbs → Under shrubs → Shrubs → Trees

Note : The **clear stratification** is found in tropical rain forest. So it is known as **multistoried forest**.

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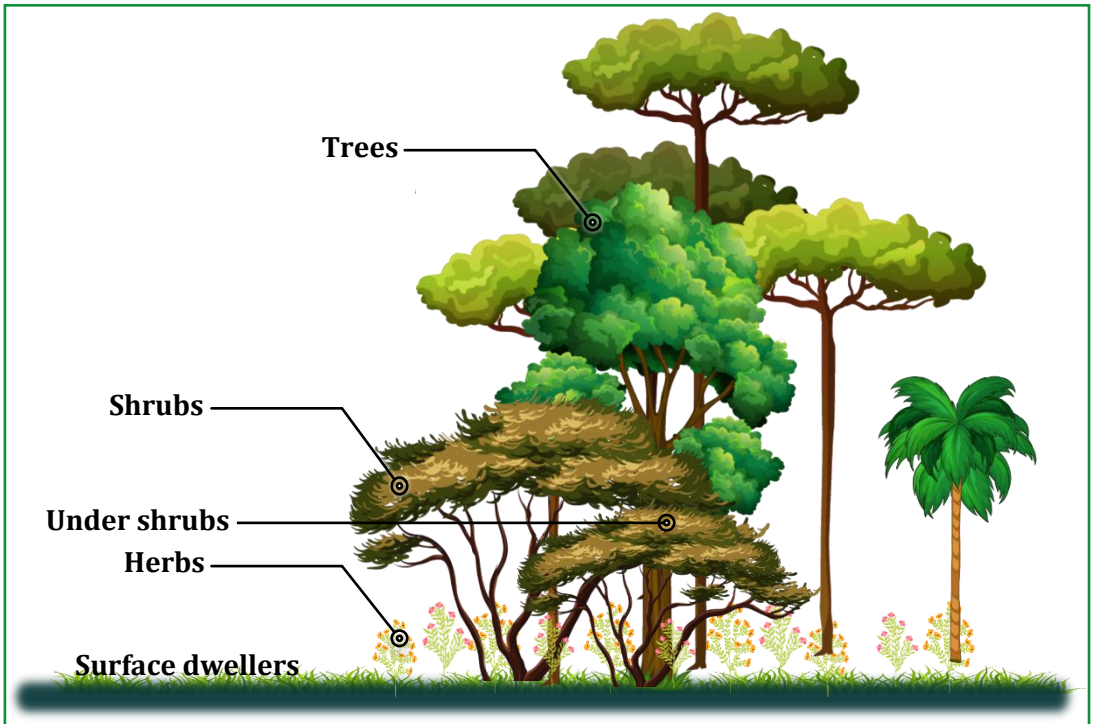
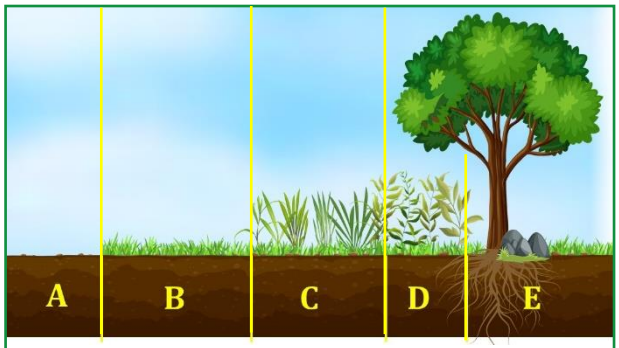


STRATIFICATION IN FOREST

(B) Ecological Succession :

Development of plant community on barren area is called ecological succession or Biotic succession. The replacement of existing community by new ones, in an orderly sequence in barren area with time due to change in environmental conditions. Biotic communities are never stable. They are changing more or less over period and space, due to presence of different types of climatic & environmental conditions. So a continuous interaction is going on between the community and environment till state of stability.



Community Development

The gradual and fairly predictable change in the species composition of a given area is called ecological succession.

(i) Term for community in succession :-

(a) Pioneer community – **The first community to inhabit an area is called Pioneer community.**

(b) Climax community – The last and stable community in an area is called climax community. This is more stable. Usually **mesophytes** are present in climax community.

An important characteristic of all communities is that composition and structure constantly change in response to the changing environmental conditions. This change is orderly and sequential, parallel with the changes in the physical environment. These changes lead finally to a community that is in near equilibrium with the environment and that is called a climax community.

(c) Seral communities or seral stage – In succession, individual communities or stages which come in between pioneer community and climax community is called transitional or seral communities.

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(d) Sere – The entire sequence of communities that successively change in a given area is called sere.

The name of sere depends on where the succession occurs or takes place.

(1)	Succession in water	**Hydrosere / Hydrarch**
	(a) Succession in salty water	**Halosere**
	(b) Succession in acidic water	**Oxalosere**
(2)	Succession at dry region	**Xerosere / Xerarch**
	(a) Succession on rocks	**Lithosere**
	(b) Succession on sand	**Psammosere**

(ii) Ecological succession shows certain characteristics :-

(a) Gradual replacement → from short lived to long lived plant.
(b) Continuous change occurs in communities towards a state of stability or climax.
(c) Increases species-diversity, biomass, niche specialization, humus content.
(d) Future seral communities can be predicted as it is a directional process.
(e) Succession and evolution would have been parallel process.
(f) Description of ecological succession usually focuses on changes in vegetation. However, these vegetational changes in turn affect food and shelter for various types of animals. Thus, as succession proceeds, the numbers and types of animals and decomposers also change.

(iii) Causes of Succession :-

(a) Biotic factors – The action of each seral community with it's environment makes the area less favourable for itself and more favourable for next seral community in the succession.

(b) Physiographic factors – These include climatic and other physical factors like soil erosion, soil deposition, landslide, volcanic lava. These all factors makes an area barren.

(iv) Types of succession :-

(a) Primary succession – Occurs in the barren area where there was no previously any type of living matter. ***e.g.*** volcanic lava **(newly cooled lava)**, igneous rock (bare rock), sand dunes, land slide, coral reefs and **newly created pond or reservoir**.

Note : It requires thousands of years.

(b) Secondary succession – This type of succession occur where vegetation was present previously but vegetation was destroyed due to natural or artificial causes i.e. fire, flood, sudden changes in climate.

e.g. **In abandoned farm lands, Burned or cut forest, Flooded land.**

In secondary succession the species that invade depend on the condition of the soil, availability of water, the environment as also the seeds or other propagules present.

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Note: This succession is comparatively more rapid, requires 50-100 years for grass land and 100-200 years for forest

(v) Hydrosere : Stages of hydrosere or hydrarch succession in the newly formed pond or lake.

(a) Phytoplankton stage – It is **pioneer community,** first coming minute autotrophic organism. These produce organic matter ***e.g.*** Soft mud diatoms, Cyanobacteria

(b) Rooted submerged stages – eg. *Vallisneria*

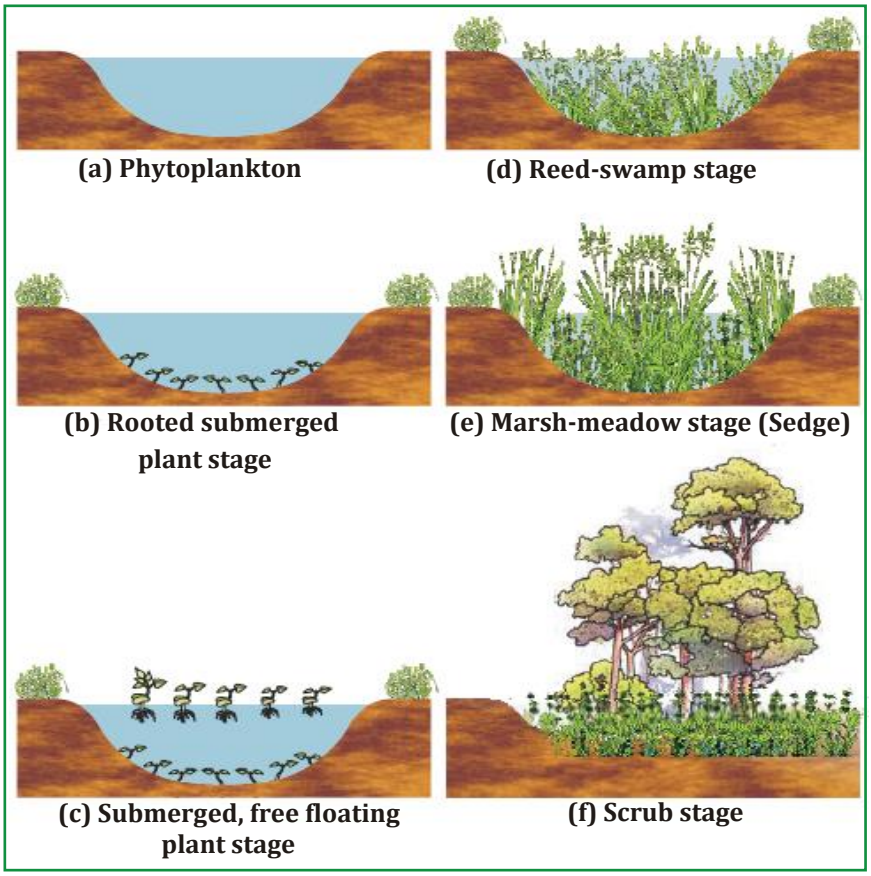
(c) Floating stages – *e.g. Nymphaea, Nelumbium, Azolla*

(d) Reed swamp stage (amphibious stage) – Most part of these rooted plants remain exposed to air ***e.g.*** *Typha*

(e) Sedge (Meadow stage or marsh meadow stage) – Muddy plants

(f) Scrub stage – Woody shrubs, tolerates water logging.

(g) Forest stage – *e.g.* Tree (Oak, *Salix*)



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(g) Forest
Diagrammatic representation of primary succession in water

(vi) **Lithosere :-** Stages of Lithosere (Succession on rocks)

(a) Crustose lichens stage– It is pioneer community, tolerates desiccation, produces organic acid which causes weathering of rocks, so first minerals are released for own use.

(b) Foliose lichens stage – large lichens with leafy thalli

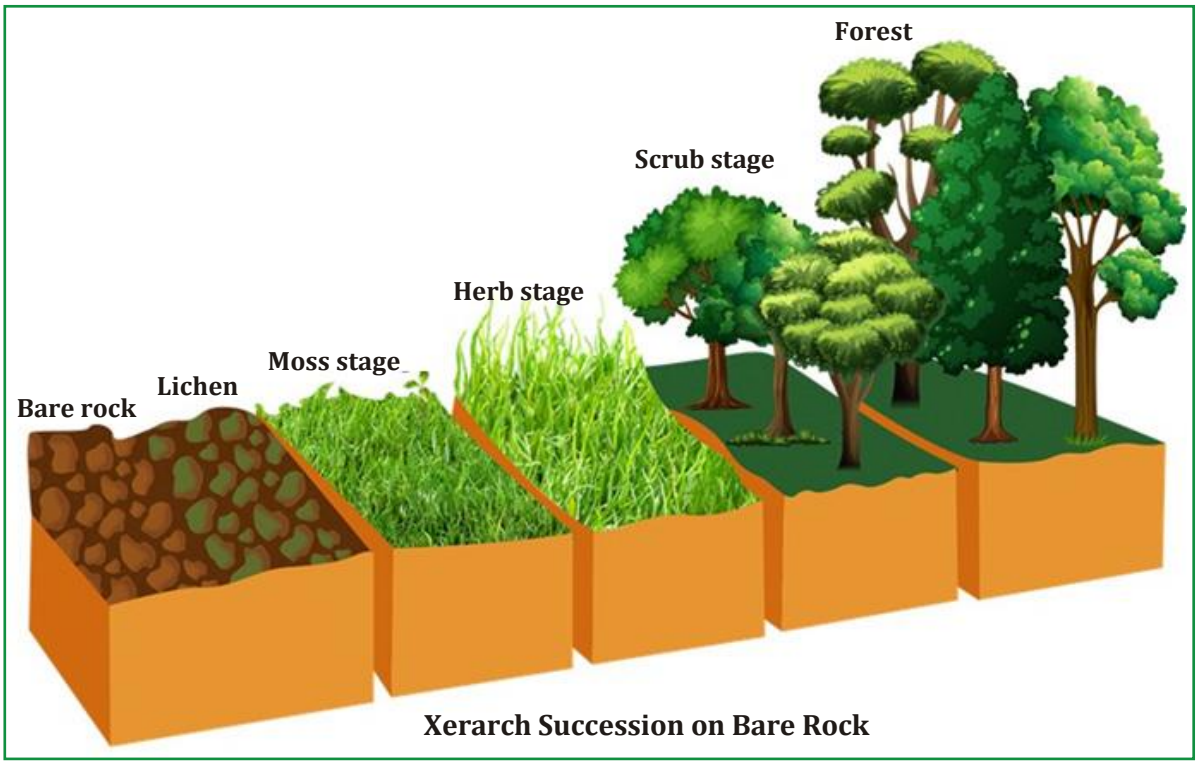
(c) Moss stage

(d) Herb stage – Annual hardy grasses

(e) Shrub stage

(f) Forest stage

Note : All succession whether taking place in water or on land, proceeds to a similar climax community - the mesic.



Xerarch Succession on Bare Rock

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Golden Key Points

- Ecology at the organismic level also known as Physiological ecology.
- The activities of key-stone species determine the structure of the community.
- Stratification of lake and forest found according to the need of light.
- The clear stratification is found in tropical rain forest.
- In succession, climax community is always mesophytes.
- Primary succession is slow while secondary succession is fast process.

BEGINNER'S BOX-1

ORGANISM, POPULATION, COMMUNITY AND SUCCESION

1. Two populations which are interconnected by dispersing individuals are known as :-
(1) Local population (2) Metapopulation
(3) Sister population (4) None

2. Kangaroo rat in desert is an example of :
(1) Keystone species
(2) Critical link species
(3) Endemic species
(4) Dominant species

3. *Pinus* community at Himalayas is an example of :
(1) Endemic species
(2) Rare species
(3) Dominant species
(4) Keystone species

4. Which of the following zone of lake stratification also known as ecotone area ?
(1) Littoral zone (2) Limnetic zone
(3) Profundal zone (4) Benthic zone

5. In which of the zone of lake stratification only heterotrophs are present ?
(1) Limnetic zone (2) Littoral zone
(3) Profundal zone (4) Ecotone zone

6. Succession on sand known as :
(1) Halosere (2) Hydrosere
(3) Lithosere (4) Psammosere

7. Which of the following is a pioneer community in Lithosere ?
(1) Phytoplankton (2) Foliose lichen
(3) Crustose lichen (4) Moss

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(C) Inter-Specific Interactions / Population Interactions :-

Due to increase in different species in community, interaction for food, habitat and light etc. also starts between them.

Species A	Species B	Name of Interaction
+ Mutualist	+ Mutualist	*Mutualism*
– Competitor	– Competitor	*Competition*
+ Predator	– Prey	*Predation*
+ Parasite	– Host	*Parasitism*
+ Host	0 Commensal	*Commensalism*
– Host	0 Amensal	*Amensalism*

(i) Positive or beneficial interaction :- Member of one or both the interacting species are benefitted but neither is harmed. It is a wide spread phenomenon, it includes → mutualism, commensalism, protocooperation

(a) Mutualism (+, +) or Obligate mutualism :-

co-evolution, co-existence and co-extinction are observed with mutualists.

Positive inter specific interaction in which members of two different species completely depend on each other for growth and survival. It is obligatory relationship.

- **Mutualism between animal and animal** – ***e.g.*** Termites and Flagellates (*Trichonympha*)
- **Mutualism between plant & animals** – ***e.g.*** *Yucca* plant flowers and female Pronuba moth Pollination of *Yucca* plant by Pronuba.
- **Mutualism between photosynthesising algae or cyanobacteria and fungi** – Lichens
- **Mutualism between fungi and the roots of higher plants** – Mycorrhiza. The fungi help the plant in the absorption of essential nutrients from the soil while the plant in turn provides the fungi with energy-yielding carbohydrates.

Lichen

- **Mutualism between Fig tree and wasp species** –In many species of fig trees, there is a tight one to one relationship with the pollinator species of wasp, It means that a given fig species can be pollinated only by its partner wasp species and no other species. The female wasp uses the fruit not only as an oviposition (egg-laying) site but uses the developing seeds with in the fruit for nourishing its larvae. The wasp pollinates the fig inflorescence while searching for suitable egg-laying sites. In return for the favour of pollination the fig offers the wasp some of its developing seeds, as food for the developing wasp larvae.

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(a) **(b)**

Mutual relationship between fig tree and wasp: (a) Fig flower is pollinated by wasp; (b) Wasp laying eggs in a fig fruit

- **Mutualism between Bees and Orchid flower** –Orchids show diversity of floral patterns, which have evolved to attract the right pollinator insect (bees and bumblebees) and ensure guaranteed pollination by it.
  The Mediterranean orchid *Ophrys* employs "sexual deceit" to get pollination done by a species of bee, One petal of its flower bears resemblance to the female of the bee in size, colour and markings. The **male bee** is attracted to what it perceives as a female, **pseudo copulates with the flower** and during that process is dusted with pollen from the flower, it transfers pollen to it and thus, pollinates the flower.

(b) **Commensalism (+, 0)** – Association between members of two different species in which one is benefitted while other is almost unaffected.

- **Lianas** – are woody plants. Their roots are present in soil but their stem use other plant or object for support to get better light. They are found in dense forest. No nutritional relationship. Lianas are the speciality of tropical rain forest. ***e.g.*** *Bauhinia*, *Tinospora*
- **Epiphytes** – Small plants grow on other plants in tropical rain forest. They utilise only the space of host plant for light & humidity
  e.g. Orchids, Hanging mosses
- **Epizoons** – Those animals which depends on plants or other animals.

Commensal		**Host**
Sucker fish (*Echeneis*)	–	Shark
Pilot fish	–	Shark
E.coli bacteria	–	Intestine of man
Clown fish	–	Sea anemone
Barnacles	–	Whale
Cattle egret birds	–	Cattle

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Barnacles on whale

Orchid on mango tree

Clown fish with sea anemone

Sucker fish on shark

Pilot fish with shark

(c) **Proto-cooperation (+/+)** – Association in which both organisms are benefited but can live separately, it is a facultative or optional or occasional association also called as non-obligatory relationship.

- Hermit crab – Sea anemone
- Tick bird (Red-billed or yellow billed) – Rhinoceros
- Crocodile – Bird

Sea anemone o Hermit crab

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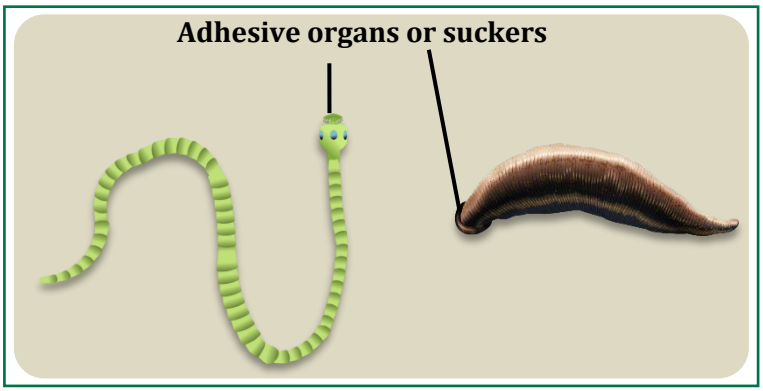
Scavenging – Association in which one partner called scavenger or saprobiont, eats the dead bodies of other animals, which have died naturally or killed by another animal
e.g. Jackal, Vulture, Ant, Crow
Helotism – Association in between two organisms, where one behaves as a master and another as slave.
e.g. Lichen

(ii) **Negative Interaction (Antagonism/Detrimental)** :-One or both interacting species is harmed.
Three type of negative interaction
(a) Exploitation
(b) Amensalism
(c) Competition

(a) **Exploitation** – One species harms the other by making its direct or indirect use for support, shelter or food.
It is of two types – Parasitism & Predation

Parasitism (+/–) : This association involves individuals of two species of different size in which smaller (Parasite) is benefitted and larger (host) is harmed. The parasite gets nourishment and shelter from host but do not kill the host.
Majority of the parasites harm the host; they may reduce the survival, growth and reproduction of the host and reduce its population density. They might render the host more vulnerable to predation by making it physically weak.
Many parasites have evolved to be host-specific (they can parasitise only a single species of host) in such a way that both host and the parasite tend to co-evolve; that is, if the host evolves special mechanisms for rejecting or resisting the parasite, the parasite has to evolve mechanisms to counteract and neutralise them, in order to be successful with the same host species. In accordance with their life styles, parasites evolved special adaptations such as the loss of unnecessary sense organs, presence of adhesive organs or suckers to cling on to the host, loss of digestive system and high reproductive capacity.



Type of Parasite :
(i) **Ectoparasite** - lives on the body of host
- **Ectozooparasite :** Leech on cattle, ticks on dogs, copepods on marine fish and lice on human.
- **Ectophytoparasite :** Aphids, Lac insects, Red cotton bug live on plants.

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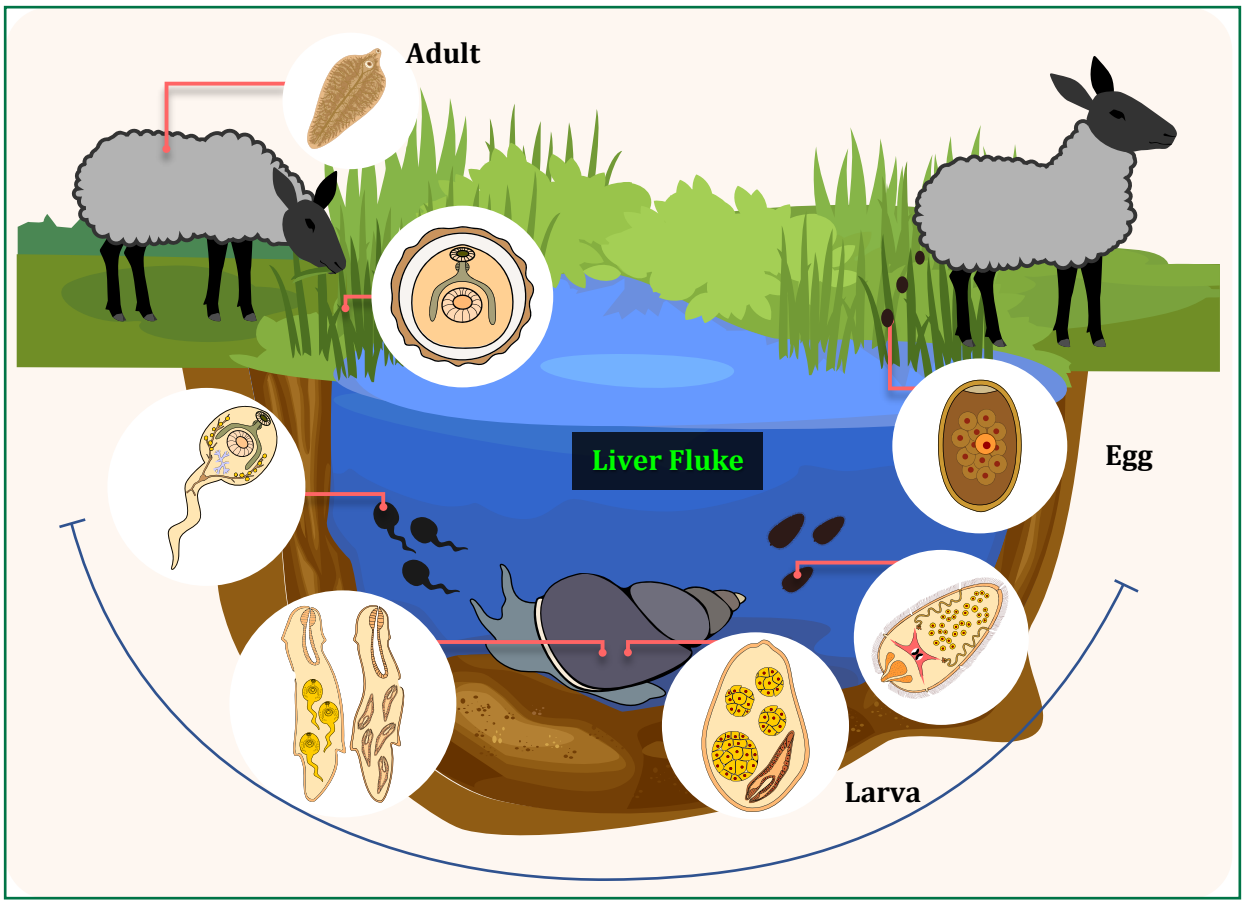
(ii) **Endoparasites :** live in the body of host at different sites (liver, kidney, lungs, red blood cells, etc.). The life cycles of endoparasites are more complex because of their extreme specialisation. Their morphological and anatomical features are greatly simplified while emphasising their reproductive potential.

Tapeworm, Taenia, Ascaris, Entamoeba □□live in intestine of man

Plasmodium → live in R.B.C. of human.

Note : The life cycle of parasite are often complex, involving one or two intermediate host or vectors to complete their life cycle.

For example : The human liver fluke (a trematode) depends on two intermediate host (snail and fish) to complete its life cycle.



Hyper parasitism → A parasite living on another parasite

e.g. Bacteriophages on bacteria.

Brood parasitism → Parasitism in which the parasitic bird (cuckoo) lays its eggs in the nest of its host (crow) and lets the host incubate them, this relation is known as brood parasitism.

Holoparasite → Parasite which are totally dependent upon the host for their requirement

e.g. *Rafflesia* (A total root parasite)

***Cuscuta* (Total stem parasite)** – a parasitic plant that is commonly found growing on hedge plants, has lost its chlorophyll and leaves in the course of evolution. It derives its nutrition from the host plant which it parasitises.

Hemiparasite → Parasite which partially depend on the host.

e.g.

Dodder (*Cuscuta*) on sedge plant

Mistletoe (*Viscum*) on host plant

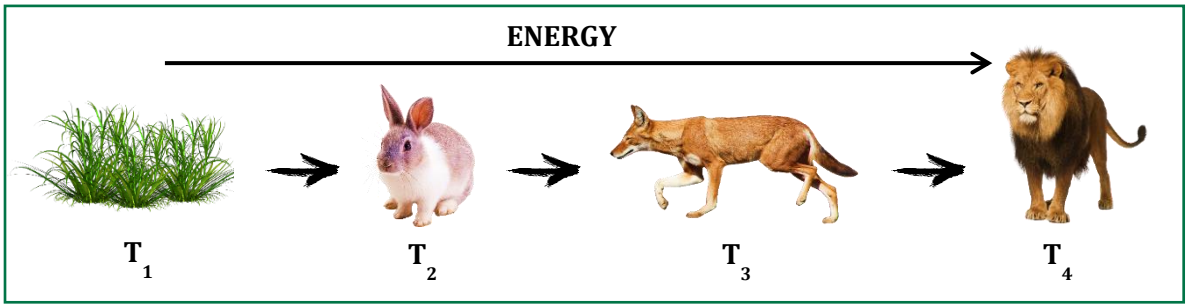
Note :

(1) *Arceuthobium* is the smallest parasitic angiosperm.

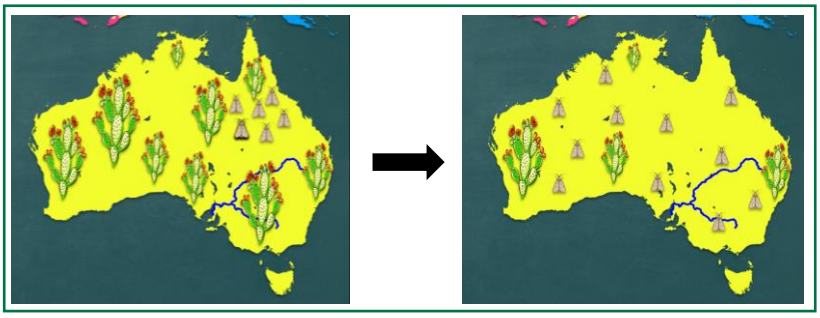
(2) Female *Anopheles* mosquito is not considered as parasite.

Predation (+/–) : A free living organisms which catches and kills another species for food.

- When we think of predator and prey, most probably it is the tiger and the deer that readily come to our mind, but a sparrow eating any seed is no less a predator.
- Predators acting as 'conduits' for energy transfer across trophic levels, also play other important roles. They keep prey populations under control. In the absence of predators, prey species could achieve very high population densities and cause ecosystem instability. When certain exotic species are introduced into a geographical area, they become invasive and start spreading fast because the invaded land does not have its natural predators.



- The prickly pear cactus introduced into Australia in the early 1920's caused havoc by spreading rapidly into millions of hectares of rangeland (grassland). Finally, the invasive cactus was brought under control only after a cactus-feeding predator (a moth) from its natural habitat was introduced into the country.



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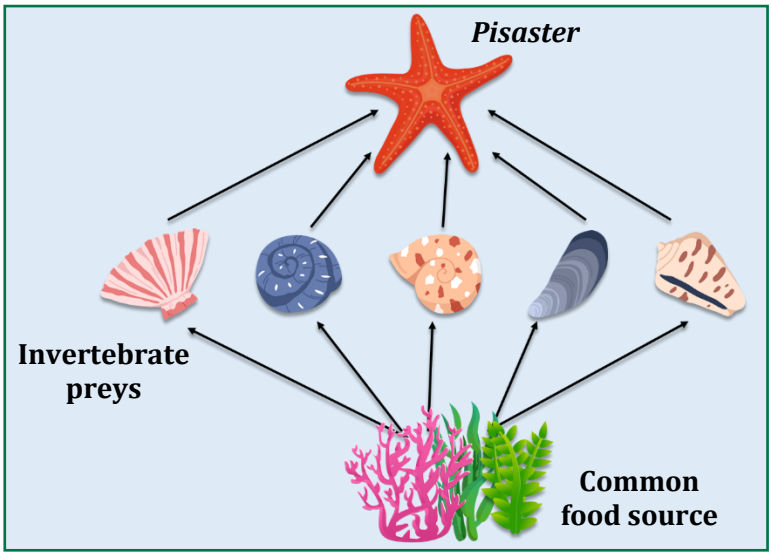
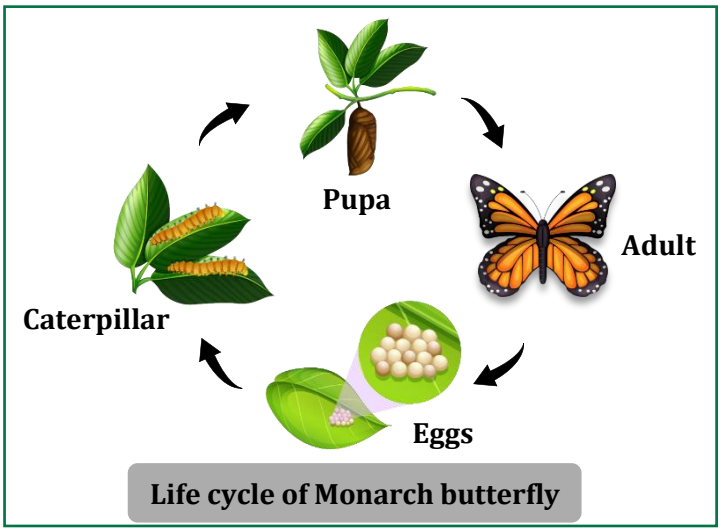
- Predators also help in maintaining species diversity in a community, by reducing the intensity of competition among competing prey species.



- In the rocky intertidal communities of the American Pacific Coast the starfish *Pisaster* is an important predator. In a field experiment, when all the starfish were removed from an enclosed intertidal area, more than 10 species of invertebrates became extinct within a year, because of interspecific competition.
- If a predator is too efficient and overexploits its prey, then the prey might become extinct and following it, the predator will also become extinct due to lack of food. This is the reason why predators in nature are 'prudent' (clever/wise).
- Prey species have evolved various defences to lessen the impact of predation. Some species of insects and frogs are cryptically-coloured (camouflaged) to avoid being detected easily by the predator. Some are poisonous and therefore avoided by the predators.

- The Monarch butterfly is highly distasteful to its predator (bird) because of a special chemical present in its body. This butterfly acquires this chemical during its caterpillar stage by feeding on a poisonous weed.



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- For plants, herbivores are the predators. Nearly 25 per cent of all insects are known to be phytophagous (feeding on plant sap and other parts of plants). The problem is particularly severe for plants because, unlike animals, they cannot run away from their predators. Plants therefore have evolved an astonishing variety of morphological and chemical defences against herbivores. Thorns (*Acacia*, Cactus) are the most common morphological means of defence.
- Many plants produce and store chemicals that make the herbivore sick when they are eaten, inhibit feeding or digestion, disrupt its reproduction or even kill it. The weed Calotropis produces highly poisonous cardiac glycosides and that is why you never see any cattle or goats browsing on this plant.

(b) Amensalism (– / 0) – In this interaction one species is inhibited by toxic secretion of other species. ***e.g.*** *Parthenium*

(c) Competition (– / –) : Process in which the fitness of one species is significantly lower in the presence of another species.

- It is generally believed that competition occurs when closely related species compete for the same resources that are limiting, but this is not entirely true.
- Firstly, totally unrelated species could also compete for the same resource. For e.g. in some shallow South American lakes, visiting flamingos and resident fishes compete for their common food, the zooplankton in the lake.

Flamingos in a lake

- Secondly, resources need not be limiting for competition to occur; in interference competition, the feeding efficiency of one species might be reduced due to the interfering and inhibitory presence of the other species, even if resources (food and space) are abundant.
- Therefore, competition is best defined as a process in which the fitness of one species (measured in terms of its 'r' the intrinsic rate of increase) is significantly lower in the presence of another species.

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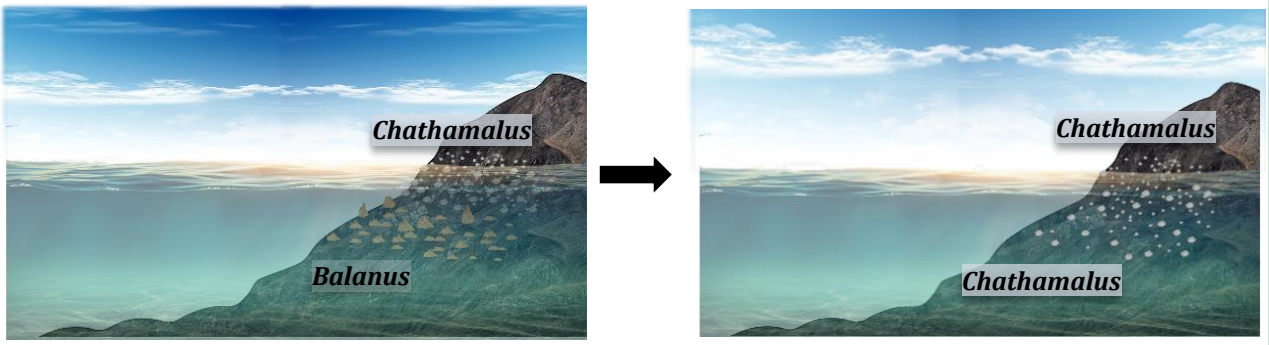
- It is relatively easy to demonstrate in laboratory experiments, as Gause and other experimental ecologists did, when resources are limited the competitively superior species will eventually eliminate the other species. The Abingdon tortoise in Galapagos Islands became extinct within a decade after goats were introduced on the island, apparently due to the greater browsing efficiency of the goats.
- Gause's 'Competitive Exclusion Principle' states that two closely related species competing for the same resources cannot co-exist long period and the competitively inferior one will be eliminated eventually. This may be true if resources are limiting, but not otherwise.
- More recent studies do not support such gross generalisations about competition. While they do not rule out the occurrence of interspecific competition in nature, they point out that species facing competition might evolve mechanisms that promote co-existence rather than exclusion. One such mechanism is 'resource partitioning'. If two species compete for the same resource, they could avoid competition by choosing, different times for feeding or different foraging patterns. MacArthur showed that five closely related species of warblers living on the same tree were able to avoid competition and co-exist due to behavioural differences in their foraging activities.
- Connell's elegant field experiments showed that on the rocky sea coasts of Scotland, the larger and competitively superior barnacle *Balanus* dominates the intertidal area, and excludes the smaller barnacle *Chathamalus* from that zone.



Connell's elegant field experiment

Another evidence for the occurrence of competition in nature comes from what is called 'competitive release'. A species whose distribution is restricted to a small geographical area because of the presence of a competitively superior species, is found to expand its distributional range when the competing species (Superior species) is experimentally removed.

Note : Interspecific competition is a potent force in organic evolution.

Ecological Niche : It is the functional role of any species in a ecosystem or community. In other words it is a occupational address or profession of a species it means it is a functional position or status in an ecosystem. Each organism has an invariably defined range of conditions that if can tolerate, diversity in the resources it utilises and a distinct functional role in the ecological system, all these together comprise its niche.

e.g. Ecological Niche of tiger : To predate on herbivores (work) under environmental conditions (abiotic and biotic factors) of forest where it resides.

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Golden Key Points

- Mutualism is obligatory relationship, in which related species show co-evolution, co-extinction and co-existence.
- In parasitism both host and parasite tend to co-evolve. If the host evolves special mechanism for rejecting or resisting the parasite, the parasite has to evolve mechanism to counteract and neutralise them.
- Predators help in maintaining species diversity in a community.
- In competition fitness of one species is significantly lower in the presence of another species.
- Gause's competitive exclusion principle states that two closely related species competing for the same resources cannot co-exist long period and the competitively inferior one will be eliminated, but this may be true if resources are limiting, but not otherwise.
- Predation, parasitism and commensalism share a common characteristic - the interacting species live closely together.
- Herbivores and plants appear to be more adversely affected by competition than carnivores.

BEGINNER'S BOX-2 — INTER SPECIFIC INTERACTIONS

1. Relation between fig tree and wasp species :

(1) Commensalism (2) Mutualism (3) Parasitism (4) Amensalism

2. Predators help in :

(1) Maintaining species diversity

(2) Reduce the competition between prey species

(3) Maintaining ecological balance

(4) All

3. Which one is example of holoparasite ?

(1) *Cuscuta* (2) *Viscum* (3) *Loranthus* (4) Sea anemone

4. Which one is example of ectoparasite :

(1) Ticks (2) *Plasmodium* (3) *Ascaris* (4) *Taenia*

5. Relation between clown fish and sea anemone :

(1) Mutualism (2) Commensalism (3) Parasitism (4) Amensalism

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DEMOGRAPHY

3. Introduction :

- Scientific study of human population is called demography.
- Population is defined as the total number of individual of a species present in a particular area at a given time.
- The population have specific character different from the character of individual.

4. Character of Population :

(A) Population Density (Population Size) :

- It is measured as total number of individual present in unit area or unit volume.
- The size of a population for any species is not a static parameter. It keeps changing in time depending on various factor including food availability, predation pressure and reduced weather.
- For human population density is officially counted in first four month of 1^{st} year of each decade is called census.
  - ➢ For human population density is calculated as number of person living in per square km area.
  - ➢ The tiger census in our national park and tiger reserves is often based on pug marks and fecal pellets.

Note : Ecological effects of any factors on a population are generally reflected in its size which may be expressed in numbers, biomass, percent cover etc. depending on the species.

(B) Birth Rate / Fertility / Natality :

➢ Birth rate is defined as total number of birth in a population with respect to total number of individual of the population in a year.

➢ Birth rate is represented as per capita birth rate

$$\text{Per capita birth rate (b)} = \frac{\text{Total number of death}}{\text{Initial population}}$$

Q. If in a pond there are 20 lotus plant last year and through reproduction 8 new plant are added, then the birth rate during the year is calculated as :	**Solution :** $b = \frac{\text{Total birth}}{\text{Initial population}}$ $= \frac{8}{20}$ b = 0.4 offspring per lotus per year.

- Birth rate varies from region to region
- Developed country have lower birth rate.
- Developing or poor country have higher birth rate than developed country
- Higher fertility in developing world is partially explained by large number of hand needed to perform work.

Note : **Biotic potential (Reproductive potential or potential ability)** → The term biotic potential was first used by **Chapmann**.

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Under most favourable environmental conditions the maximum reproductive capacity of an species is known as biotic potential.

Vitality – Capacity of normal growth and reproduction for survival of a species. It depends upon weight of plant, stem height, root length, leaf number etc.

(C) Death Rate / Mortality :

- Death rate is defined as total number of death in a population with respect to total number of individual of the population in a year.
- Death rate is represented as per capita death rate

$$d = \frac{\text{Total number of death}}{\text{Initial population}}$$

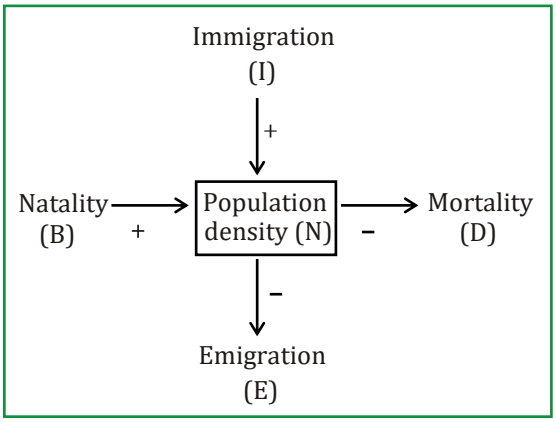
Q. If 4 individuals in a laboratory population of 40 fruit fly died during week. The death rate is calculated as:	**Solution :** $d = \frac{\text{Total number of death}}{\text{Initial population}} = \frac{4}{40}$ d = 0.1 individual per fruit fly per week.

(D) Growth Rate :

Intrinsic growth rate (r) = b – d

$$\text{Growth rate} = \frac{\Delta N}{\Delta t}$$

$$\text{Percent growth rate} = \frac{\left(\frac{\Delta N}{\Delta t}\right)}{N_0} \times 100$$



Note : Natality, Mortality, Immigration and Emigration are the basic process responsible for fluctuation in population size under normal conditions, Natality and Mortality are the most important factors influencing population size than other two factor i.e., Immigration and Emigration.

$N_{t+1} = N_t + [(B + I) – (D + E)]$

(E) Age-Sex Structures :

- The age structure of a given population refers to the proportion of individuals of different age. This is important aspect because **many functional aspect of individuals are related to age**. (Like Reproduction)
- Age structure of a population can be depicted in the form of a pyramid diagram.
- Diagram is particularly important in **understanding future growth.**
- Population has 3 age groups.

Pre-Reproductive individuals – < 15 yr
Reproductive individuals – 15 – 44 yr
Post-Reproductive individuals – > 45 yr

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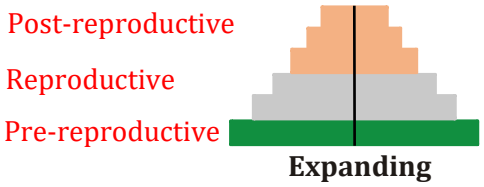
(i) Expanding population :

A **higher number of pre-reproductive** individuals, moderate number of reproductive individuals and fewer post reproductive individuals will form young population it shows **rapid growth.**



(ii) Stable population :

An **equal number** of pre-reproductive and reproductive individuals will constitute a mature population or **stable population.**

(iii) Declining population :

Fewer number of pre-reproductive individuals as compared to reproductive ones will make population aged. It shows **negative growth.**

Note : Developed countries have a steeper pyramid which represent nearly a stable population.

5. Population Growth Models / Curve :

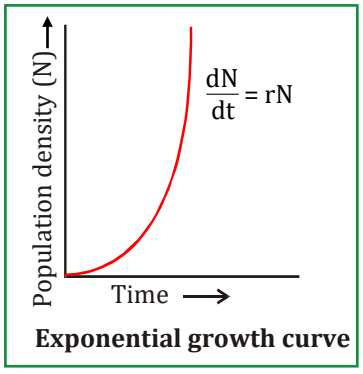
There are two type of growth curve

(A) Exponential Growth (Geometric Growth Curve or J-Shaped Curve)

- Any species growing exponentially under unlimited resource conditions can reach enormous population densities in a short time. If in a population of size "N", the birth rates are represented as b and death rates as d, then the increase in N during a unit time period $t\left(\frac{dN}{dt}\right)$ will be.

$$\frac{dN}{dt} = (b - d) \times N \quad \text{Let } (b - d) = r, \text{ then}$$

$$\boxed{\frac{dN}{dt} = rN}$$



r = intrinsic rate of Natural increase or Fitness or growth rate.

The integral form of the exponential growth equation as :-

$$N_t = N_0 e^{rt}$$

where :

N_t = Population density after time t

N_0 = Population density at time zero

r = intrinsic rate of natural increase

The magnitude of r-values for the Norway rat is 0.015 and for the flour beetle it is 0.12. In 1981, the r-value for human population in India was 0.0205.

e = the base of natural logarithms (2.71828)

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(B) Logistic Growth Curve (Sigmoid Curve/S-Shaped)

- Since resources for growth for most animal population are finite and become limiting sooner or later, the logistic growth model is considered more realistic.
- The S-shape sigmoid growth form is represented by the **Verhulst - Pearl logistic growth** equation:

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

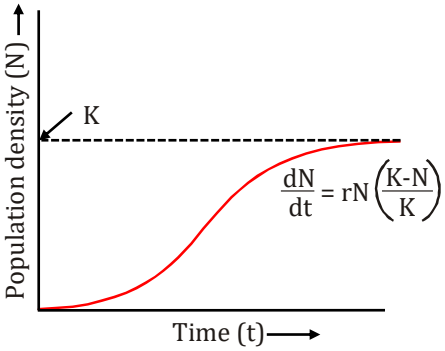
where : $\frac{dN}{dt}$ = Rate of change in population size

r = Intrinsic rate of natural increase

N = Population size at time t

K = Carrying capacity

$\left(\frac{K-N}{K}\right)$ = Environmental resistance



Logistic growth curve

6. Life History Variation :

- Population evolve different strategy to maximise their reproductive fitness.
- Some organisms breed only once in their life time like **Pacific salmon fish, Bamboo** etc.
- Some produce small sized offspring like **Oyster, Pelagic fishes** etc. maximise their fitness by producing large number of offspring.
- Some organisms breed many times in their life and produces a small number of large sized offspring **(Birds, Mammals)**.

BEGINNER'S BOX-3 DEMOGRAPHY

1. _____ contribute to an increase in population density.
(1) Natality and emigration
(2) Mortality and emigration
(3) Mortality and immigration
(4) Natality and immigration

2. Which of the following factor would not limit the growth of population?
(1) food scarcity (2) Immigration (3) Parasites (4) Catastrophe

3. Carrying capacity is denoted as -
(1) r (2) N (3) K (4) I

4. Which growth model is considered as more realistic one?
(1) Exponential growth (2) Constant growth
(3) Logistic growth (4) None of these

5. To calculate the current r value for human population we need to know about -
(1) Birth rate (2) Death rate
(3) Carrying capacity (4) Both (1) and (2)

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BEGINNER'S BOX ANSWERS KEY

BEGINNER'S BOX-1	Que.	1	2	3	4	5	6	7
	Ans.	2	1	3	1	3	4	3

BEGINNER'S BOX-2	Que.	1	2	3	4	5
	Ans.	2	4	1	1	2

BEGINNER'S BOX-3	Que.	1	2	3	4	5
	Ans.	4	2	3	3	4

⇒ Organism $\rightleftharpoons$ Environment
$\Downarrow$
Ecology

⇒ Ecology is basically concerned with four levels of biological organisation.

- Organism
- Populations
- Community
- Biomes

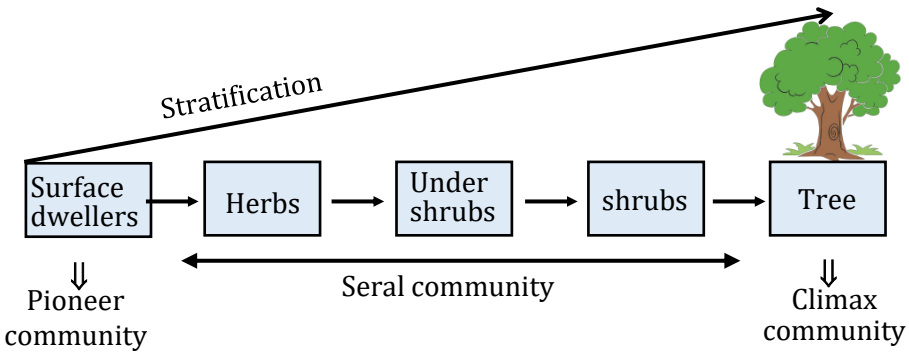
⇒ Ecology at the organismic level is essentially physiological ecology.

⇒ Population of organism inhabiting a particular area is called local population 'or' demes.

⇒ Biotic community = Animal community + Plant community + Plant community + Microbial community

Characteristics of a community

1. Species diversity
2. Dominance
3. Stratification



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⇒ Both biotic and abiotic factors are responsible for succession.

⇒ Succession ultimately leads to climax community which is usually mesophytes.

Types of succession

Primary succession
* Occurs in a barren area. (no soil)
e.g. Volcanic lava
Bare Rock
Newly created pond.

Secondary succession
* Occurs in area where soil is present.
e.g. Abundant farm land Burned 'or' cut forest Flooded land.

Mutualism	**Commensalism**	**Protoco-operation**
• Yucca and Pronuba moth • Lichen • Mycorrhiza • Fig tree and wasp species	• Orchid & Mango • Clown fish & Sea Anemone • Barnacles and whale • Cattle egret birds & cattle.	Hermit crab-seaanemone Tick Bird – Rhinoceros Crocodile – Bird

Parasitism (+,–) : depends on its host for food and shelter.

Types of Parasite

Ectoparasite

Ectozoo Parasite
* On the animal
• Tick on
• animal
• Leech on cuttle

Ectophyto Parasite
On the plant

Holo Parasite
Rafflesia (total root parasite)
Cuscuta (total stem parasite)

Hemi Parasite
Viscum – on oak
Loranthus – on mango

} both are partial stem parasite

Endoparasite

Endozoo Parasite
* Into the animal body
⇒ *Taenia*
⇒ *Ascaris*
⇒ *Plasmodium* lives on RBC of human.

Endophyto Parasite
* Into the plant body
⇒ *Agrobacterium tumifaciens*

Brood Parasitism :- Parasite Bird (Cucco) ⟶ egg in crow's Nest → crow incubate.

Predation (+, –) :

e.g. Lion Hunting deer.
Cow eating grass.
Sparrow eating seed.

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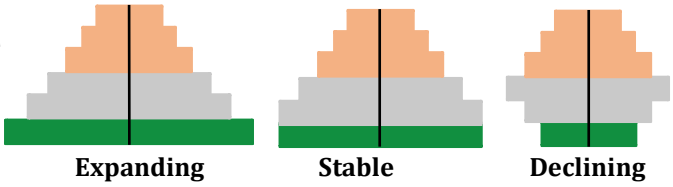
Competition :-

Gause competition exclusion principle (for limited resources)

- Extinction
  - Abingdon tortoise ⇓ Inferior
  - Goat ⇓ Superior
  - → extinction with in one decade
- Exclusion
  - Barnacle *chathamalus* → Small → inferior
  - Barnacle *Balanus* → Large → Superior
  - Superior exclude inferior

Age structure

Post-reproductive
Reproductive
Pre-reproductive



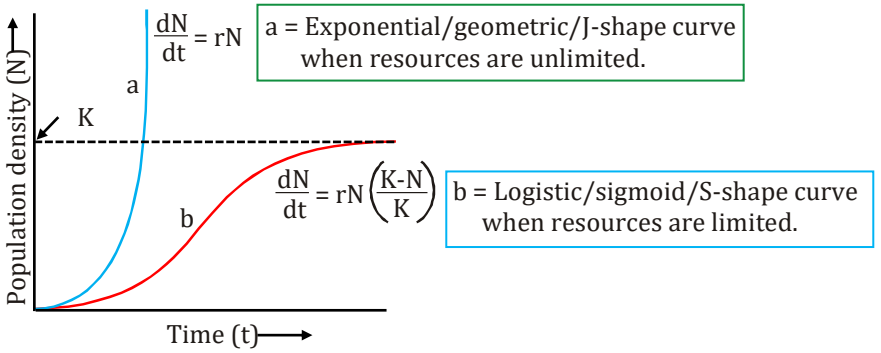
Expanding **Stable** **Declining**

Character of population

(i) Population size
(ii) Natality
(iii) Mortality
(iv) Growth rate
(v) Age-sex Structure

DEMOGRAPHY

Population growth curve



a = Exponential/geometric/J-shape curve when resources are unlimited.

b = Logistic/sigmoid/S-shape curve when resources are limited.